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ECONOMICS OF FORAGE BASED PRODUCTION SYSTEMS FOR SASKATCHEWAN

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EXECUTIVE SUMMARY

A 5-year grazing study was initiated at the Western Beef Development Center's Termuende Research Ranch near Lanigan, Saskatchewan to evaluate forage yield and quality, plant energy reserves, animal performance and economic returns of grazing perennial forages. Perennial grasses included in the study were 'Carlton' smooth bromegrass, 'Paddock' meadow bromegrass, 'AC Knowles' hybrid bromegrass, 'AC Goliath' crested wheatgrass, 'Courtenay' tall fescue and a long established stand of crested wheatgrass. Study results will provide additional information on grazing capacity of these forage cultivars and an economic comparison to annual cropping systems.

Cumulative dry matter yield differences were observed between species with AC Goliath crested wheatgrass and AC Knowles hybrid bromegrass consistently producing greater yields in most years. In addition, hybrid bromegrass and meadow bromegrass had greater total yield over the 5-year period. All bromegrasses had similar crude protein, neutral detergent fiber, acid detergent fiber and *in vitro* organic matter digestibility levels. In most years tall fescue had similar forage quality to bromegrass and wheatgrass species. The results of this study suggest that forage quality is greater for new varieties compared to long established (>40 yr) crested wheatgrass stands.

Spring etiolated regrowth is an indication of plant energy reserves. AC Goliath crested wheatgrass produced the greatest etiolated regrowth, suggesting this species is well-suited for early spring grazing. In contrast, meadow bromegrass and hybrid bromegrass produced less etiolated regrowth than crested wheatgrass. Therefore, these species may not be well suited for early spring pasture but have good potential for summer grazing.

Livestock producers need perennial grasses that will produce high animal gains when used for summer pasture. Data from this study suggests that grazing all species can produce acceptable animal performance when grassing stockers. Decreased forage availability during late summer or early fall may lead to decreased animal gains in a second grazing period as observed in other studies. There were minimal differences between animal grazing days and total beef production for brome grasses, suggesting that these species can be utilized for summer pasture. However, in 2007, hybrid bromegrass, meadow bromegrass and tall fescue produced more grazing days per hectare, than the control (>40 year old) pastures.

AC Goliath crested wheatgrass, AC Knowles hybrid bromegrass and Courtenay tall fescue pastures showed comparable average daily gain amongst all species. Despite reduced for tall fescue in 2006, it appears that this species can still produce many animal grazing days. Total beef production was also similar among species even though tall fescue was not grazed a second time. Thus, livestock producers must realize that even though tall fescue has tremendous animal production potential, the production may be very seasonal (early to mid summer) and there may be limitations as to when they can successfully graze this species. Grazing tall fescue may require more detailed grazing management to optimize its grazing potential in the Lanigan region.

Over the 5 years of the study, forage based production systems had similar or greater returns per hectare compared to growing spring wheat or feed barley during a similar time and location. Annual cash outlay and financial risk was much higher in the annual cropping systems compared to the perennial grass pastures. However, growing annuals had the potential to produce higher gross revenue than the forage based systems. Economic analysis of the perennial forage systems indicated that grazing control (>40 yr) stands of crested wheatgrass) may generate negative returns due to decreased biomass production and beef production per hectare. Similarly, smooth bromegrass generated negative returns over most years of the study suggesting that other species such as AC Goliath crested wheatgrass, Paddock meadow bromegrass and Courtney tall fescue may be better options for summer grazing, as these species generated positive returns. When comparing average net returns from growing spring wheat, grazing hybrid bromegrass or tall fescue pastures generated 44 and 67% greater profit over the long term. As the price of annual crops per bushel increases, comparisons between perennial forages and annual crops would favor the latter. When annual crop prices are low grazing systems may generate better returns.

Based on the results of this study, beef producers can graze stocker cattle on seeded perennial grass pastures during the grazing season and expect to maintain adequate levels of animal performance and pasture production. This study has demonstrated that three bromegrasses, crested wheatgrass and tall fescue work well in a complementary grazing system while other seeded forages or native rangeland can fill the late summer to early fall grazing period.

INTRODUCTION

In the past decade, the number of forage acres in western Canada has been increasing as many producers have shifted to larger livestock operations due to variable margins in producing annual crops. Furthermore, initiatives such as the Greencover Canada program (Agriculture and Agri-Food Canada, Government of Canada) have provided financial incentives and access to technical expertise for producers to increase the number of hectares in perennial cover in Canada. As part of the program, livestock producers were encouraged to seed perennial forages and adopt beneficial management practices on their operation. While this program recently ended, other programs such as the Canada-Saskatchewan Environmental Farm Plan (Canadian and Saskatchewan Government), have continued to encourage producers to seed perennial cover and manage their operations in an environmentally sustainable manner. Other agencies such as Ducks Unlimited Canada have also developed programs to help livestock producers with land conversion. As producers convert their land to perennial forages for grazing, they need access to timely and relevant information that will help them choose the forage species and varieties that will be best suited to their livestock operation.

While all forage varieties must demonstrate merit before they are commercially released to livestock producers, the majority of variety testing occurs in small-plot format. Small plot trials use mechanical methods of defoliation, such as mowing or clipping. Mechanical treatments fail to impose grazing animal effects, such as pulling, treading, manure and urine deposition and short stubble heights, which may cause different responses than frequent clipping (McCartney and Bittman 1994). Few grass forage species have been evaluated for livestock performance and stand persistence under grazed conditions before being commercially released. Recognition of the differences between small-plot results and actual results under grazing situations has lead to the current study where new varieties are compared to a standard, long established crested wheatgrass stand.

Historically, crested wheatgrass (*Agropyron cristatum*) and smooth bromegrass (*Bromus inermis*) have been used as both a hay and pasture species in western Canada. The high quality, early spring growth of crested wheatgrass makes it suitable for use in complementary grazing systems. Crested wheatgrass is very drought tolerant, winter hardy and tends to persist for long periods of time. Smooth bromegrass is an up-right growing, rhizomatous perennial grass that forms a dense sod. A native to Western Europe, this species is extremely winter hardy and is drought and heat tolerant. Since its introduction to North America in the 1880's, smooth bromegrass has been widely used as both hay and pasture species, but its slow regrowth makes it more suited to hay production (Smith et al. 1986).

More recently, meadow bromegrass (*B. riparius*), hybrid bromegrass (*B. riparius* x *B. inermis*) and tall fescue (*Festuca arundinacea*) have been examined for their pasture potential in western Canada. Meadow bromegrass, a bunch-type grass, shows increased regrowth compared to smooth bromegrass, and the basal nature of the leaves makes this species more suitable for pasture rather than hay production. This species is

often used in mixtures with alfalfa and other legumes but there is little published data on forage and livestock performance in pure stands (Knowles et al. 1993). Breeding programs initiated at the Saskatoon Research Centre of Agriculture and Agri-food Canada generated hybrid bromegrass, which is a cross between smooth and meadow bromegrass. This species was selected to have characteristics that are intermediate to the two parental lines (Coulman 2004) and has been shown to be suitable for hay and pasture production (Knowles and Baron 1990). Tall fescue is a deep-rooted, bunch-type grass which is less winter-hardy than smooth bromegrass. Its forage quality persists into the fall and it has been demonstrated to provide excellent fall and winter grazing forage (Smith et al. 1986). This species is generally adapted to humid, temperate areas of the world, and its stand persistence in the western Canada climate is unknown.

A 5-year study was initiated at the Western Beef Development Center's Termuende Research Ranch near Lanigan, Saskatchewan to evaluate the five above-mentioned perennial grasses for forage quality and yield, animal performance, grazing capacity, total beef production and economic return to a livestock operation.

Finally, the objectives of this study are to:

1. To determine yield and quality of new and existing forages under grazed conditions in the Thin Black/Dark Brown soil zone of Saskatchewan.
2. Determine grazing animal performance, grazing capacity and beef production per hectare from new forage varieties.
3. Determine economic and net return/acre from forage/beef systems compared to growing cereal crops.

GENERAL MATERIALS AND METHODS

Study Site

During the grazing seasons of 2004 to 2008, a 5-year grazing study was conducted on 11.2 ha of seeded pastures near Lanigan, Saskatchewan (51°51′N; 105°02′W) at the Western Beef Development Center's Termuende Research Ranch (Appendix Figure A.1). Topography at the study site (NW-22-33-21-W2) is gently to moderately hummocky and the soils are a mixture of Oxbow Orthic Black and carbonated Oxbow with a loam texture (Saskatoon Institute of Pedology 1992).

The objective of this study was to evaluate forage yield and quality, steer performance and grazing capacity, plant energy reserves and economic performance of five perennial grass species under grazed conditions.

Forage Establishment

In 1999, two 0.8 ha replicates each of meadow bromegrass (MBG) (*Bromus riparius* Rehm.) cv. Paddock, smooth bromegrass (SBG) (*Bromus inermis* Leyss.) cv. *Carlton* and hybrid bromegrass (HBG1) (*B. riparius* x *B. inermis*) cv. *AC Knowles* were established. Prior to seeding, the site was sprayed with glyphosate at 2.0 kg ha^{-1} of

active ingredient to facilitate weed control. Following herbicide application, the seedbed was prepared by cultivation with a light tandem disc. Seeding rates were 10 kg ha^{-1} for smooth bromegrass and 12 kg ha^{-1} for meadow bromegrass and hybrid bromegrass. Some over seeding was required on these paddocks in May 2000 due to patchy establishment. Post-seeding weed control included spot spraying of 1.1 kg ha^{-1} of active ingredient propyzamide for control of foxtail barley (*Hordeum jubatum*) in the fall. In the spring, 9.88 g ha^{-1} of active ingredient thifensulfuron methyl and 4.94 g ha^{-1} of active ingredient tribenuron methyl was applied for control of broadleaf weeds.

In 2003, two 0.8 ha replicates each of crested wheatgrass (CWG) (*Agropyron cristatum* (L.) Gaertn.) cv. *AC Goliath*, hybrid bromegrass (HBG2) cv. *AC Knowles* and tall fescue (TF) (*Festuca arundinacea* Schreb.) cv. *Courtenay* were established adjacent to the 1999 seeded pastures. Prior to seeding, glyphosate was applied at 0.879 kg ha^{-1} of active ingredient. The seed bed was prepared by two passes with a light tandem disc. Seeding rates were 10, 11.2 and 5 kg ha^{-1} for the crested wheatgrass, hybrid bromegrass and tall fescue, respectively. Fifty-six kg nitrogen (N) ha^{-1} was applied with the seed at seeding. Post-seeding weed control included 0.288 kg ha^{-1} of active ingredient fenoxaprop-p-ethyl, 0.334 kg ha^{-1} of active ingredient bromoxymil and 0.198 kg ha^{-1} of active ingredient tralkoxydim. Some over seeding was required on the tall fescue paddocks in 2004 due to variable establishment. In addition and adjacent to the seeded pastures, two 0.8 ha paddocks of a long established crested wheatgrass (CONTROL) (cultivar unknown) were managed as **control** pastures (Plot Plan Appendix Figure A.1).

Pasture and Animal Management

Each spring soil samples were taken to determine soil N, phosphorus (P), potassium (K) and sulfur (S) levels. Prior to grazing and based on lab results, all paddocks were fertilized with 79 kg actual N ha^{-1} and 23 kg actual P ha^{-1} each spring via coulter disc application according to soil test results.

Each year, 84 crossbred yearling steers, averaging 295±4 kg body weight (BW), were stratified by weight, tagged to allow individual identification, and randomly assigned to 1 of 14 treatment pastures.

Grazing of experimental pastures by cross-bred yearling steers commenced when available forage was approximately 20 cm high (4-5 leaf stage). With the exception of tall fescue and control, all species were grazed in 2004. In 2008 all species were grazed except SBG, MBG and HBG1. These species were taken out of production due to poor and patchy growth and invasive species. Crested wheatgrass and CONTROL paddocks were grazed in May due to the growth characteristics and early maturity of the species. The mid-season species were grazed June through July.

Prior to the start of trial, steers were allowed to graze a common pasture type. Individual paddocks were separated with electric fencing and water was provided *ad libitum* to all paddocks in stock troughs through surface pipelines. Steers also had *ad libitum* access to cobalt iodized salt and a 1:1 range mineral (Feed Rite, Division of Ridley, Inc.) in mineral feeders on pasture (Appendix Table A.1). Steers were implanted with RALGRO™ (36 mg zeranol; Schering Canada Inc.), a growth promoting hormone

each year and given 30 mL of Megamectin™ (ivermectin; Novartis Animal Health Canada Inc.) for control of internal and external parasites. Steers were also vaccinated with Covexin™-8 (8-way modified live *Clostridial* vaccine; Schering-Plough Animal Health Corp.) and STARVAC™ 4 Plus (a modified live BVD, PI3, IBR, BRSV vaccine; Novartis Animal Health Canada Inc.). All animals were handled according to the Guidelines of the Canadian Council on Animal Care (1993).

Steers were weighed over 2 consecutive days at start (SOT) and end (EOT) of trial and every 7 d during the trial. Steers were weighed at a consistent time each day, but were not fasted due to the lack of appropriate holding facilities. Paddocks were managed using a "put and take" grazing system with 3 randomly chosen tester steers per paddock (Mott and Lucas 1952). "Put and take" steers were added or removed from paddocks to maintain similar forage availability in each pasture type. Steers remained on each pasture until plants were grazed to a uniform level of approximately 8 centimeters.

Environmental Conditions

Monthly average precipitation and temperature were recorded at a meteorological station at the Termuende Research Ranch, Lanigan, Saskatchewan. Data not collected at Termuende was obtained from Environment Canada. Total precipitation at the study site from April to September was 310.1, 297.6, 263.0, 235.9 and 268.2 mm for 2004, 2005, 2006, 2007 and 2008, respectively. The 30-year average for the Lanigan area is 278.9 mm. Near average or above normal levels of total rainfall were observed in all years except 2007.

Mean monthly temperatures for April, May, June, July, August, and September were 4.0, 7.4, 13.4, 17.1, 14.0, and 11.6 °C in 2004; 5.9, 9.6, 14.9, 17.8, 15.6, and 11.9 °C in 2005; 6.4, 11.7, 16.8, 19.4, 18.0, and 11.9 °C in 2006; 3.5, 11.5, 15.4, 20.8, 15.4, and 10.5 °C in 2007; and 2.1, 7.5, 15.3, 17.3, 17.9, and 11.7 °C in 2008. The 30-year average temperature for April to September is 3.2, 11.2, 16.1, 18.4, 17.7, and 11.5 °C for the Lanigan area. Mean monthly temperatures were similar to long-term averages except in May and August of 2004, 2005 and 2008 when cooler temperatures were observed.

Statistical Analysis

The grazing experiment (steer gain, grazing days, beef production), yield and quality estimates were a randomized complete block design with the 5 grasses as treatments with 2 pasture replicates. Year or grazing period was considered to be a random blocking effect. Statistical analysis was conducted using SAS Mixed procedure for analysis of variance (SAS Institute Inc. 2005). Where significant differences were indicated ($P<0.05$), means were separated at the 5% level of significance using Tukey's procedure (Steel et al. 1997).

RESULTS AND DISCUSSION

YIELD AND QUALITY OF FORAGE SPECIES UNDER GRAZED CONDITIONS

Forage Yield and Quality

Available forage (kg dry matter (DM) ha^{-1}) was measured at start of each grazing period by clipping three 0.25 m^2 quadrats to a stubble height of 2.5 cm. Cumulative dry matter yield (CDMY) was determined in each paddock using the cage comparison technique (Klingman 1943). Each paddock had 3 randomly placed grazing exclusion cages allocated prior to grazing. On weekly sampling days, available forage was determined by clipping 1, 0.25 m^2 quadrat inside and 1, 0.25 m^2 quadrat outside each cage to a height of 2.5 cm. Broadleaf weeds were hand-separated and discarded at the time of clipping and were not included in CDMY measures. After clipping, cages were randomly repositioned within the paddock. Previously harvested areas were not re-harvested. CDMY was determined for each paddock using the following formula:

> CDMY = start of trial initial growth + (Week 1 inside cage clip – start of trial initial growth) + (Week 2 inside cage clip – Week 1 outside cage clip) + (Week 3 inside cage clip – Week 2 outside cage clip) + ... (Thompson et al. 2003).

Forage DM was determined by oven drying all samples in a forced draught oven at 55 °C until a constant weight was reached. In preparation for forage quality analysis, all forage samples were ground through a Wiley mill and stored in sealed plastic bags prior to lab analyses.

Laboratory Analyses

Lab tests for forage quality included crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and in vitro organic matter digestibility (IVOMD) at the start, end and middle of each grazing period according to calendar date. Clippings from outside the exclusion cages were used for forage quality analyses. Crude protein was analyzed using a Leco FP428 Nitrogen Analyzer (Leco Corporation, St. Joseph, MI). Neutral detergent fiber and ADF were determined using an ANKOM 200 Fiber Digestor (ANKOM Technology, Fairport, NY). The IVOMD of available forage was determined using a modified Tilley and Terry (1963) technique (Troelsen and Hanel 1966). The artificial saliva recipe used in the IVOMD analyses was that of Baumgardt et al. (1962). Fistulated steers used for the collection of rumen fluid were fed a standard bromegrass hay forage diet and cared for in accordance with the Canadian Council on Animal Care guidelines (CCAC 1993). Only pasture samples from 2004 to 2006 were analyzed for IVOMD.

Statistical Analysis

Each experiment was a randomized complete block design with 5 grass species as treatments and two replicates per grass species. Year or grazing period was considered to be a random blocking effect. Differences in forage quality were analyzed separately at three times; at the start, middle and end of each grazing period. Cumulative dry matter yield and forage quality analyses were analyzed using the MIXED procedure of SAS for analysis of variance (SAS Institute Inc. 2005). Where significant differences were indicated ($P<0.05$), means were separated at the 5% level of significance using Tukey's procedure (Steel et al. 1997).

Results and Discussion

Cumulative Dry Matter Yield

Cumulative dry matter yield (CDMY) for all forages is presented in Table 1. TF and control paddocks were not grazed in 2004. In fall 2007, HBG1, SBG and MBG paddocks were desiccated and taken out of production due to patchy growth and invasive species.

Due to a high standard error in 2004, there were no differences ($P>0.05$) in CDMY between forage species. However, HBG1 produced numerically greater CDMY than the other grasses. HBG1 produced twice as much CDMY compared to Goliath CWG. Mean CDMY in 2004 was similar for smooth and meadow bromegrass species ($P>0.05$). In 2004, HBG1 produced 20 and 23% more CDMY than SBG and MBG, respectively. In 2005, 'AC Goliath' CWG produced greater ($P<0.05$) CDMY than the other species. AC Goliath yields were twice that of the control pastures. HBG1, TF, SBG and HBG2 produced 82, 58, 29 and 26% more CDMY than control, respectively.

Despite similar CDMY of some species in 2006 to 2008 ($P>0.05$), numeric difference were observed between grasses. In 2006, HBG1, MBG, TF and HBG2 produced 39, 39, 30 and 17% more CDMY than control, respectively. In 2007, HBG2, MBG, TF, CWG, and HBG1 produced 61, 55, 39, 39 and 35% more CDMY than control, respectively. Finally, in 2008, CWG and TF both produced 42% more CDMY than control pastures.

Finally totaled over all years, new forage varieties produced superior yields compared to control paddocks. Tall fescue, smooth bromegrass, crested wheatgrass, meadow bromegrass and hybrid bromegrass produced 37, 40, 63, 74, 79 and 114% greater total yield than the control pasture.

Table 1. Cumulative dry matter yield of grasses under grazed conditions (kg ha $^{-1}$)

Item[z]	CWG	HBG1	HBG2	SBG	MBG	TF	CONTROL	SEM[y]
2004	4484	9228	8967	7499	7333	-	-	1437
2005	7514*a*	4533*b*	3136*b*	3197*b*	2868*b*	3932*b*	2484*b*	754
2006	3293	5217	4381	3879	5712	4887	3744	668
2007	5985	5777	6878	4455	6617	5931	4281	545
2008	4639	-	3928	-	-	4635	3261	457
TOTAL	18401	20222	24154	15833	19662	15454	11286	

[z]CWG=Goliath crested wheatgrass; HBG1=AC Knowles hybrid bromegrass seeded 1999; HBG2=hybrid bromegrass seeded 2003; SBG=Carlton smooth bromegrass; MBG= Paddock meadow bromegrass; TF=Courtenay tall fescue; Control=crested wheatgrass.
[y]SEM = standard error of the mean.
a-b Means in the same row with different letters differ ($P<0.05$).

Forage Quality

Lab analysis of forage samples for CP, NDF, ADF and IVOMD at the start, middle and end of grazing periods are presented in Tables 2 and 3. Forage sampling times were chosen to best represent changes in quality over the grazing season.

In 2004, there were no differences ($P>0.05$) in forage crude protein levels. However, in 2005 protein levels were different ($P<0.05$) early in the grazing period. At start of grazing, tall fescue, hybrid bromegrass, meadow bromegrass and smooth bromegrass had higher protein compared to control pasture suggesting better quality pasture early in the season. This was also observed early in the grazing season in 2007 and 2008 but not 2006. In 2006, forage protein was different ($P<0.05$) between species in the middle of the grazing season. Finally, protein levels (Tables 2 and 3) were similar among all study pastures at the end of grazing ($P>0.05$).

Differences were observed in NDF and ADF levels at the start, middle and end of the grazing between study species in this study ($P<0.05$). Fiber levels of all pasture species increased as growing season advanced. Fiber levels of tall fescue forage were lower in most years at the end of grazing season. This would suggest tall fescue could provide adequate quality late season grazing.

In 2004, all forages had similar ($P>0.05$) IVOMD. *In vitro* organic matter digestibility was greater ($P<0.05$) for all bromegrass species in 2005 and for MBG and HBG in 2006 compared to the control pastures. The average IVOMD of bromes, TF and CWG at mid maturity period of 2005 and 2006 was greater than the control pastures ($P<0.05$) (Table 2).

In all established grasses, CP and IVOMD decreased and NDF and ADF concentration increased as the grazing season progressed. These results are similar to an earlier study which reported whole plant nutritive values for MBG, SBG and three cultivars of HBG at 3 stages of plant maturity - vegetative, heading and anthesis (Ferdinandez and Coulman 2001). At the vegetative stage of growth, Ferdinandez and Coulman (2001) reported that HBG had consistently lower NDF and ADF values than either MBG or SBG, but there was no consistent trend as these species matured. Other literature has suggested that MBG has marginally lower forage quality than smooth bromegrass (Knowles et al. 1993), but this trend was less evident as the species matured.

With advancing plant maturity, changes occur to the chemical composition of plant parts and within the sward structure of grass pastures, causing the nutritive value to decrease (Collins and Fritz 2003). Kilcher and Troelsen (1973) showed that the decline in forage nutritive value with advancing maturity in smooth bromegrass resulted primarily from a decrease in the leaf:stem ratio, a decline in the CP concentration and an increase in the cell wall lignin concentration of the whole-plant. In addition, the leaf component maintained lower lignin content and higher CP, gross energy and *in vitro* digestible energy content throughout the growing season compared to the stem component.

Table 2. Nutritive value of grasses at early, mid and late maturity under grazed conditions at Lanigan, Saskatchewan (2004-2006)

Species	Crude Protein (%)			Neutral Detergent Fibre (%)			Acid Detergent Fibre (%)			In Vitro Organic Matter Digestibility (%)		
2004	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
CWG[z]	18.0	10.3	9.0	51.7	63.5*a*	64.5*a*	29.6*a*	37.2*a*	39.0*a*	71.7	58.4	54.5*c*
HBG1	18.6	11.2	8.9	49.1	56.3*b*	60.7*bc*	25.9*b*	30.0*b*	33.0*c*	69.7	64.3	56.8*b*
HBG2	15.5	11.4	9.0	53.8	58.2*b*	61.6*bc*	30.6*a*	34.6*a*	35.3*b*	68.3	59.9	57.5*b*
MBG	17.9	10.5	9.2	49.7	55.3*b*	59.0*c*	26.4*b*	31.1*b*	32.7*c*	70.2	63.4	59.3*a*
SBG	19.6	10.5	7.8	49.0	56.6*b*	62.7*ab*	25.1*b*	30.1*b*	33.9*bc*	70.5	62.5	57.4*b*
SEM	2.19	1.24	1.04	1.30	0.96	0.78	0.69	0.82	0.52	0.76	1.14	0.49
2005												
Control	12.9*b*	11.8	13.2	59.3*a*	62.3*a*	61.7*ab*	30.3*a*	32.7*a*	32.0*c*	57.6*c*	54.9*c*	54.0
CWG	21.6*a*	15.1	12.2	52.0*b*	59.0*b*	59.4*bc*	25.8*cd*	31.7*ab*	32.3*c*	68.9*b*	64.4*a*	53.3
HBG1	22.2*a*	13 7	9.1	52.7*b*	58.7*b*	62.1*a*	27.0*bcd*	30.0*cd*	34.3*ab*	68.7*b*	64.2*a*	56.9
HBG2	20.9*a*	11.2	10.0	53.3*b*	60.7*ab*	63.2*a*	27.3*abc*	32.9*a*	35.9*a*	68.7*b*	59.9*b*	56.7
MBG	17.5*ab*	12.9	12.1	52.8*b*	59.1*b*	57.9*c*	29.0*ab*	30.9*bc*	31.4*c*	67.4*b*	63.5*a*	61.9
SBG	20.5*a*	14.0	10.5	54.3*b*	58.8*b*	63.5*a*	27.8*abc*	30.2*bcd*	34.9*a*	66.7*b*	62.8*ab*	54.7
TF	22.2*a*	13.0	11.5	47.5*c*	55.6*c*	58.9*c*	24.1*d*	29.3*d*	32.4*bc*	73.2*a*	65.2*a*	59.9
SEM	1.47	0.75	0.79	1.29	0.72	0.76	0.90	0.45	0.57	1.21	0 93	3.11
2006												
Control	17.1	10.0*d*	7.8	53.2	61.4*a*	58.7*c*	26.4	31.7*a*	31.1*c*	64.0	55.4*c*	55.5
CWG	19.1	17.4*a*	12.2	48.6	54.7*c*	64.8*a*	24.4	27.6*b*	36.8*a*	66.0	68.7*a*	52.6
HBG1	19.8	12.4*bcd*	10.7	52.7	60.1*ab*	61.5*bc*	25.9	31.8*a*	33.5*b*	67.2	59.8*b*	54.4
HBG2	20.8	13.0*bc*	10.0	51.2	59.5*ab*	62.5*ab*	25.9	30.8*a*	34.0*b*	68.1	60.2*b*	55.6
MBG	20.4	11.2*cd*	8.4	52.3	58.1*b*	60.7*bc*	27.2	31.2*a*	34.5*b*	67.9	60.4*b*	55.3
SBG	19.2	12.7*bc*	12.7	54.7	59.8*ab*	61.2*bc*	26.7	31.9*a*	33.7*b*	64.8	58.7*bc*	54.5
TF	17.7	14.1*b*	9.1	52.0	59.6*ab*	61.4*bc*	25.7	31.3*a*	33.1*bc*	65.1	58.4*bc*	53.3
SEM	1.50	0.79	1.37	1.07	0.63	0.83	0.91	0.67	0.68	0.93	1.22	1.01

[z]Control=crested wheatgrass; Crested wheatgrass=AC Goliath; Hybrid bromegrass1=AC Knowles seeded 1999; Hybrid bromegrass2=AC Knowles seeded 2003; Meadow bromegrass=Paddock; Smooth bromegrass=Carlton; Tall fescue=Courtenay.

[y]SEM = standard error of the mean.

a-d Means in the same column with different letters differ ($P<0.05$).

Table 3. Nutritive value of grasses at early, mid and late maturity under grazed conditions at Lanigan, Saskatchewan (2007-2008)

Item[z]	Crude Protein (%)			Neutral Detergent Fibre (%)			Acid Detergent Fibre (%)		
	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
2007									
Control	17.9*c*	12.4	9.9	54.9	62.6*a*	68.0	28.0	33.9	37.4
CWG	19.6*ab*	13.1	10.1	52.6	60.5*ab*	64.3	27.5	33.0	36.0
HBG1	22.3*a*	14.1	10.3	55.4	58.5*bc*	66.5	25.2	30.9	37.3
HBG2	23.7*a*	14.4	10.0	49.9	57.9*bc*	67.9	26.3	31.0	37.0
MBG	20.8*a*	11.5	8.8	55.2	56.1*c*	59.2	27.1	32.8	36.4
SBG	18.1*abc*	10.2	7.4	55.8	60.6*ab*	67.0	26.7	33.3	38.6
TF	18.5*ab*	12.5	7.6	53.4	59.6*bc*	60.0	26.4	30.5	36.8
SEM	1.19	1.01	0.94	0.93	0.96	0.78	1.21	0.82	0.92
2008									
Control	16.5*b*	11.6	8.7	55.7*ab*	62.3	68.9*a*	28.6	34.1	38.7*a*
CWG	20.8*a*	13.5	10.7	53.5*b*	60.3	65.4*b*	27.3	32.3	35.8*b*
HBG1	-	-	-	-	-	-	-	-	-
HBG2	20.3*a*	13.7	10.2	59.1*a*	61.8	63.1*b*	27.9	30.4	33.4*b*
MBG	-	-	-	-	-	-	-	-	-
SBG	-	-	-	-	-	-	-	-	-
TF	19.5*a*	16.3	11.7	55.5*b*	58.4	61.6*c*	27.1	31.3	33.8*b*
SEM	1.02	0.79	0.97	1.08	0.83	0.99	1.01	0.97	1.22

[z]Control=crested wheatgrass; Crested wheatgrass=AC Goliath; Hybrid bromegrass1=AC Knowles seeded 1999; Hybrid bromegrass2=AC Knowles seeded 2003; Meadow bromegrass=Paddock; Smooth bromegrass=Carlton; Tall fescue=Courtenay.

[y]SEM = standard error of the mean.

a-d Means in the same column with different letters differ ($P<0.05$).

ENERGY RESERVES OF FORAGE SPECIES UNDER GRAZED CONDITIONS

Forage Management

A study was conducted during the spring and summer of 2006 and 2007 to estimate etiolated regrowth (stored energy reserves) of grazed and non-grazed plants for five grasses after the 2005 and 2006 grazing seasons. Forage species included control pasture (>40 yr stand of crested wheatgrass), meadow bromegrass (cv. Paddock), smooth bromegrass (cv. Carlton), hybrid bromegrass (cv. AC Knowles), crested wheatgrass (cv. AC Goliath) and tall fescue (cv. Courtenay).

Etiolated regrowth was measured according to the technique described by Lardner et al. (2003). During the 2005 and 2006 grazing seasons, a grazing exclusion cage was randomly placed in each species pasture prior to grazing to exclude grazing. In the spring of 2006 and 2007, 3 grazed and 3 non-grazed plants were randomly selected in each paddock for etiolated growth measurements.

In early spring (13 April 2006 and 14 April 2007), plant tufts were identified, clipped to a 3 cm height (Matches 1969) and covered with white metal cans (13.5 cm diameter, 25 cm height). Before plants were covered, basal tuft circumference was measured with meter tape to account for differences in etiolated regrowth and tuft size. Cans were pushed into the soil and secured with plastic strapping to reduce the possibility of tipping due to wind or animal activity.

Fourteen days after covering, plants were clipped and every 7 d until etiolated growth ceased in 2006 and 2007, respectively. Final clipping dates each year were 16 July 2006 and 15 July 2007. In both years, many plants had ceased etiolated regrowth prior to the final clip date. All samples were dried in a forced air oven at 55 °C until a constant weight was reached, removed and weighed. Etiolated regrowth was expressed as mg per cm^{-2} of basal tuft area. Etiolated regrowth of individual species and grazed effects are presented in Tables 4 and 5, respectively.

Results and Discussion

Differences ($P<0.05$) in etiolated regrowth were seen in 2006 but not ($P>0.05$) in 2007 (Table 4). In the spring and summer of 2006, AC Goliath CWG produced greater ($P<0.05$) etiolated regrowth than other grasses including control plants.

In 2006, all bromes had similar total etiolated regrowth ($P>0.05$) while smooth bromegrass, meadow bromegrass and hybrid bromegrass had greater ($P>0.05$) total etiolated regrowth compared to control pastures. In 2007, total etiolated regrowth for bromes and control pastures was similar ($P>0.05$).

Table 4. Etiolated regrowth of grass species (mg cm^{-2})

Item[z]	CWG	HBG1	HBG2	SBG	MBG	TF	CONTROL	SEM
2006	78.2*a*	41.7*b*	51.8*b*	40.3*b*	32.8*b*	46.2*b*	20.2*b*	2.59
2007	28.2	12.7	22.1	22.0	16.4	15.6	14.7	3.56

[z]Control=crested wheatgrass; Crested wheatgrass=AC Goliath; Hybrid bromegrass1=AC Knowles seeded 1999; Hybrid bromegrass2=AC Knowles seeded 2003; Meadow bromegrass=Paddock; Smooth bromegrass=Carlton; Tall fescue=Courtenay.
Pooled standard error of the mean.
a-b Least square means in the same row within treatment with different letters differ at $P<0.05$

Table 5. Etiolated regrowth of grazed and un-grazed plants (mg cm^{-2})

Item[z]	Grazed	Ungrazed	SEM[z]
2006	42.8*a*	24.8*b*	4.86
2007	13.1	19.8	1.47

[z]Pooled standard error of the mean.
a-b Least square means in the same row within treatment with different letters differ at $P<0.05$

AC Goliath crested wheatgrass had the greatest energy reserves which may account for the early spring growth of this species observed in this trial. Ranking the species in relation to energy reserves places *AC Goliath* crested wheatgrass first, followed by *AC Knowles* hybrid bromegrass, *Courtenay* tall fescue, *Carlton* smooth bromegrass, *Paddock* meadow bromegrass and lastly, the control plants (long established crested wheatgrass). Assuming that the amount of etiolated regrowth produced corresponds to energy reserves, *AC Goliath* crested wheatgrass and *AC Knowles* hybrid bromegrass could provide greater spring regrowth and greater winter hardiness than either *Courtenay* tall fescue or long established stands of crested wheatgrass.

Lardner et al. (2003), working with irrigated pasture, did not find any significant correlations between etiolated growth and CDMY or between etiolated growth and regrowth rates of eight irrigated perennial grasses in Saskatchewan. Richards and Caldwell (1985) suggested that current photosynthesis and leaf area could offset the effect of reduced energy reserves available for growth. Meadow bromegrass possesses basal leaf growth which may escape defoliation and continue to photosynthesize. Additionally, presence of basal meristems may provide some explanation as to why this grass has high regrowth potential despite low etiolated growth or energy reserves

In crested wheatgrass, McKendrick and Sharp (1970) reported that etiolated growth per individual tiller did not show a good relationship to subsequent herbage yield; however, individual tiller weight appeared to reflect the previous year's grazing treatment. Locations that had been grazed the previous year had decreased etiolated growth compared to ungrazed locations. As the number of years without grazing increased, so did the etiolated growth weight (McKendrick and Sharp 1970). McKendrick and Sharp (1970) also reported that there was a high correlation ($r=0.97$) between etiolated growth per plant and subsequent herbage yield. In general, there is a seasonal pattern of TNC accumulation in the plant which can be altered by grazing. Typically, TNC levels are lowest during the periods of rapid growth when quantities of photosynthates are insufficient to initiate and sustain plant growth, and highest when plants are in a positive energy balance (photosynthetic supply exceeds growth and respiration demands) later in the growing season; however, once a plant is grazed the normal phenological development of the plant is disrupted (Trlica and Cook 1972).

Total etiolated regrowth for grazed plants was greater ($P<0.05$) than un-grazed plants in 2006 (Table 5). However, total etiolated growth produced by grazed and un-grazed plants was similar in 2007 ($P>0.05$). In 2005, it was observed that plants that were grazed in June through mid-July had a larger quantity of green, vegetative material that appeared to be actively growing in mid-August to mid-September compared to the ungrazed plants where the majority of these plants appeared to be mature and senesced. Thus, plants that had been grazed in 2005 may have been actively photosynthesizing and storing energy in the fall while the un-grazed plants may have had decreased rates of photosynthesis or may have already been using energy that was stored earlier in the growing season for normal plant metabolism.

The last date that steers had access to the pastures in 2005 was 14 July. Because no grazing occurred on pastures after mid-July, there would have been sufficient time

for plants to replenish energy reserves prior to winter senescence. Reynolds and Smith (1962) used 3 cutting regimes to monitor change in total available carbohydrates in smooth bromegrass, timothy and alfalfa. Regardless if forages were defoliated twice (27 June and 29 July) or 3 times (3 June, 18 July and 29 August) in their study, carbohydrate levels of defoliated plants in October exceeded the levels of non-defoliated plants. Forage species which are able to maintain energy reserves while producing new plant growth may have an advantage in the next growing season (Lardner et al. 2003). Also, it is important to manage forage stands by avoiding defoliations that are too frequent or severe, as insufficient recovery time between defoliations may limit the ability of the plant to rebuild energy reserves.

STEER PERFORMANCE AND GRAZING CAPACITY OF FORAGES

Experimental Animals and Grazing Management

Each year, grazing commenced when available forage was approximately 20 cm high (4 to 5 leaf stage). Crested wheatgrass pastures were grazed in May due to the growth characteristics and early maturity of the species. The mid-season species were grazed June through July. Only one grazing period occurred in 2005, however, in 2006, a second grazing period occurred on both replicates of *AC Goliath* crested wheatgrass pastures (mid-July to mid-August), both replicates of hybrid and smooth bromegrass and replicate of one meadow bromegrass (mid-August to early-September). Prior to the start of trial and between grazing periods, steers were allowed to graze a common grass pasture.

From 2004 to 2008, British × Continental steers were stratified by body weight and randomly allocated to one of 14 pasture types. Steers were weighed over 2 consecutive days at the start and end of trial and every 7 d throughout the course of each grazing period. The weights of steers ranged from 255 ± 5 kg to 335 ± 6 kg (mean ± SD). Steers were weighed at a consistent time each day, but were not fasted due to the lack of appropriate holding facilities.

Pastures were managed using a "put and take" grazing system with 3 randomly chosen tester steers per paddock (Mott and Lucas 1952). Tester steers remained on their designated pastures for the duration of the grazing period while "put and take" steers were added or removed from pastures to maintain similar forage availability and maturity in each pasture type. Steers remained on each replicate paddock until plants were grazed to a uniform height of approximately 8 cm. Thus, steers were removed from pastures on varying calendar dates dependent upon forage availability.

Average daily weight gain was determined using the average start and end of trial body weights of the 3 tester steers in each paddock. Animal grazing days per ha was determined using both tester and 'put and take' animals. Animal grazing days were calculated as:

$$AGD = \frac{\Sigma(\text{animal unit equivalents} \times \text{days on pasture})}{\text{pasture area}}$$

Total beef production per ha was calculated for each pasture as:

TBP = ADG of the tester steers × AGD (Mott and Lucas 1952).

Results and Discussion

Steer Performance, Grazing Capacity and Total Beef Production

Animal performance, grazing capacity and beef production data for 2004 to 2008 are presented in Table 6. In 2004 control and TF paddocks were not grazed. In 2008 no data was collected from the SBG, MBG and HBG1 grasses as plots were terminated fall 2007 due to uneven growth and presence of invasive species. Differences were observed in average daily gain (ADG) for species between grazing years ($P<0.05$).

Average Daily Gain

Steer average daily gain was similar for all species in all years (Table 6). Steer gain was anticipated to be high for CWG as this species is known for high quality and reserves in the spring (Tables 3 and 4). Performance of grazing animals is dependent upon a number of factors, including forage quality and intake, with forage intake influenced by forage quality (Hart et al. 1983). Therefore, grazing perennial grasses in the spring and early summer when forage quality is greatest (Tables 2 and 3) and intake is not limiting may result in high animal performance. The steer performance data in this study are similar to the results reported by Thompson et al. 2003.

Based on grazing trials at the Melfort, Saskatchewan, Knowles et al. (1993) reported that animal gains were comparable between meadow and smooth bromegrass during the June through August time period, but were superior for meadow bromegrass during the August through October time period. More recent grazing trials at Lanigan, Saskatchewan, have also reported similar ADG between smooth bromegrass, meadow bromegrass and hybrid bromegrass during the summer grazing season (Thompson et al. 2003). Average daily gains ranged from 0.53 to 1.25 kg d^{-1}, 0.78 to 1.36 kg d^{-1} and 0.74 to 1.62 kg d^{-1} for smooth bromegrass, meadow bromegrass and hybrid bromegrass, respectively (Thompson et al. 2003). Variation between the present study and previously reported data may be a result of differences in forage quality, environment or animal grazing characteristics. Additionally, a short grazing period combined with high forage quality and potential compensatory growth of the tester steers may have attributed to the high ADG observed in the present study.

Table 6. Steer performance and grazing capacity of perennial grasses pastures.

Item[z]	CWG	HBG1	HBG2	SBG	MBG	TF	CONTROL	SEM[y]
Average daily gain (kg d^{-1})[v]								
2004	1.3	1.3	1.4	1.2	1.4	-	-	0.21
2005	1.7	1.5	0.7	1.2	1.2	1.3	1.7	0.39
2006	1.3	1.4	1.2	1.1	1.2	0.9	1.4	0.17
2007	1.3	1.4	1.4	1.3	1.4	0.9	1.0	0.22
2008	1.0	-	1.0	-	-	0.8	0.8	0.19
Animal grazing days (AUD ha^{-1})[w]								
2004	124*b*	163*a*	140*ab*	163*a*	163*a*	-	-	2.1
2005	215*a*	252*a*	232*a*	221*a*	235*a*	229*a*	78*b*	10.4
2006	215*bc*	303*a*	235*b*	243*b*	301*a*	375*a*	148*c*	19.5
2007	252*b*	296*b*	344*a*	288*b*	320*b*	344*a*	148*b*	15.3
2008	198	-	216	-	-	216	228	12.9
Beef production (kg ha^{-1})								
2004	174	212	182	171	224	-	-	16.2
2005	351*a*	309*a*	190*ab*	271*a*	281*a*	316*a*	125*b*	43.1
2006	316*a*	351*a*	280*ab*	212*b*	340*a*	329*a*	230*b*	40.7
2007	331*ab*	425*a*	362*ab*	322*a*	386*a*	471*a*	219*b*	23.6
2008	202*ab*	-	230*ab*	-	-	383*a*	129*b*	20.5

[z]CWG=Goliath crested wheatgrass; HBG1=AC Knowles hybrid bromegrass seeded 1999; HBG2=hybrid bromegrass seeded 2003; SBG=Carlton smooth bromegrass; MBG=Paddock meadow bromegrass; TF=Courtenay tall fescue; Control=crested wheatgrass.

[y]SEM=pooled standard error of the mean.

[w]AUD, animal unit day, based on 1 animal unit (455 kg).

a-c Least square means in the same row with different letters differ at $P<0.05$

Lack of differences (P<0.05) in steer gain in this study may be a result of minimal replication per species, thus the experimental design may not have been sensitive enough to detect differences. Steers used in the study were cross-bred animals with individual variation which may have had a greater effect on average daily gain rather than pasture type. Finally, based on the forage quality and yield data presented in Tables 1 and 2, it could be assumed that all pasture species involved in the study provided similar levels of nutrition and available forage, which may explain the observed similar animal gains.

Animal Grazing Days

All grazing capacity data for each species was converted to animal units equivalents (AUE) to account for differences in steer body weight (AUE = $BW^{0.75}/ 455^{0.75}$) and is expressed as AGD per hectare (animal unit days (AUD) ha^{-1}).

In 2004, HBG1, SBG, MBG had greater (P<0.05) number of AGD's than CWG and HBG2 pastures (Table 6). In 2005, all bromegrass species had a significantly greater number of AGD than the control pastures (P<0.05) (Table 6). Additionally, CWG and TF also had greater (P<0.05) AGD than control paddocks. Total AGD in 2006 was similar for HBG1, MBG and TF (P>0.05). However, hybrid bromegrass, tall fescue and meadow bromegrass produced greater AGD compared to the control pastures (P<0.05).

In 2005, *AC Goliath* crested wheatgrass, hybrid bromegrass and tall fescue pastures all had greater (P<0.05) AGD than the crested wheatgrass control pastures (Table 6). In 2006 and 2007, tall fescue had the greatest AGD compared to other grasses and control (P<0.05) (Table 6). Animal grazing days were similar (P>0.05) in 2008. When describing tall fescue, Balasko (1986) stated that "much of the increase of tall fescue in recent years has been related to its ability to provide more grazing days per year than other tall growing cool season grasses." Balasko (1986) also indicated that tall fescue may be well-suited to spring, fall and winter grazing as a lack of palatability may limit its use for summer pasture. As *Courtenay* is an endophyte-free variety, it is possible that it lacks some drought and heat tolerance of the varieties that contain endophytes, as the endophytes typically improve plant persistence, heat and drought tolerance (Hoveland et al. 1997). Tall fescue may lack the drought tolerance of crested wheatgrass and bromegrass species.

Despite low animal grazing days for the control (long established crested wheatgrass) pastures in the current study, Cohen et al. (2004) demonstrated that it's possible to obtain much higher AGD on crested wheatgrass when it is heavily fertilized (> 100 kg N ha^{-1}). In a long-term grazing study evaluating the effects of nitrogen fertilizer on performance of pregnant yearling heifers at Lanigan, Saskatchewan, daily gain ranged from 0.34 to 1.23 kg d^{-1} while animal grazing days ranges from 92 to 499 AUD ha^{-1} with higher AGD typically the result of timely precipitation and high nitrogen fertilization (Cohen et al. 2004). In the current study, it appears that *AC Goliath* with moderate fertility (79 kg N ha^{-1}, 23 kg P ha^{-1}) has similar or greater steer gains to the more highly fertilized, older established varieties of crested wheatgrass. Finally, it was expected that over the 5-year study, all pasture varieties would produce greater AGD than the control pastures due mainly to stand age.

Total Beef Production

In 2004, TBP was similar (P>0.05) for all pasture types. Total beef production was greater for TF, SBG, MBG, HBG1 and CWG compared to control (P<0.05). In some cases seeded perennials produced twice as much beef per hectare as the control paddocks. This would suggest to maximize beef production from forage systems, stand age, yield and quality (Tables 2 and 3) needs to be considered. In 2006, meadow bromegrass and hybrid bromegrass paddocks produced greater TBP compared to smooth bromegrass and control pastures (P<0.05).

For the grazing seasons of 2006 and 2007, meadow bromegrass, tall fescue and hybrid bromegrass produced 340, 329 and 351 kg ha^{-1} and 386, 471 and 425 kg ha^{-1} respectively (P<0.05). In grazing trials at Melfort, Saskatchewan, Knowles et al. (1993) reported TBP of meadow bromegrass and smooth bromegrass pastures to be 458 and 404 kg ha^{-1}, respectively. Thompson et al. (2003) reported AGD and TBP to be similar among hybrid, meadow and smooth bromegrass species. Animal grazing days and TBP values for the current study are considerably higher than those reported by Thompson et al. (2003) but not as high as those reported by Knowles et al. (1993). Differing results between the three studies may be a result of differences in environmental conditions prior to and during the grazing season as well as stand age differences.

In 2006, CWG, HBG1, TF and MBG produced similar TBP (P>0.05). Tall fescue produced the greatest TBP due to the large number of grazing days (329 and 471 AUD ha^{-1}) and a moderate ADG (0.9 kg d^{-1}) in 2006 and 2007. In a 3-year grazing study evaluating endophyte-infected and endophyte-free tall fescue in central Georgia, Hoveland et al. (1997) reported TBP to be 99 and 285 kg ha^{-1} and 124 and 159 kg ha^{-1}, for spring and fall grazing periods, respectively. In one year of the study they were not able to obtain a fall (second) grazing period similar to the current study.

In a put-and-take grazing system, such as the management used in this study, it is often difficult to determine a stocking rate (steers per ha) that will be similar for the entire grazing period. However, a measure such as AGD will provide insight as to the carrying capacity of the pasture. For all grass pastures, stocking rates varied from 5 steers ha^{-1} for control pastures to 17.5 steers ha^{-1} for tall fescue. The combined AGD for all steers was 148 and 375 AUD ha^{-1} for control and tall fescue pastures, respectively. With higher stocking rates observed for the tall fescue paddocks, overall individual animal gain was decreased compared to the lower stocking rates observed for the control paddocks. However, overall TBP in tall fescue paddocks was much higher than in control paddocks.

In a similar study evaluating performance of animals grazing meadow foxtail (*Alopecurus pratensis* L.) and timothy (*Phleum pratense* L.), Rode and Pringle (1986) reported that even though timothy had fewer AGD than meadow foxtail, timothy was able to produce 28% greater TBP due to higher individual steer gains. Similarly, Jones and Sandland's (1974) model suggests that individual gain may be sacrificed at higher stocking rates but there is the potential to maximize overall animal gain on the pasture with an optimum stocking rate. Therefore, if one refers to Jones and Sandland's (1974) model, it is likely that the grass species in the current experiments would be consistent

with the linear relationship between individual animal gain and stocking rate as well as the quadratic relationship between gain per hectare and stocking rate.

ECONOMICS OF FORAGE AND CROP BASED PRODUCTION SYSTEMS

Introduction

Pasture forages are an integral part of the beef industry in Western Canada. While forage production factors such as yield and quality are important for determining pasture grazing capacity and animal performance, it is also important to consider the economic costs and returns of these systems. Depending on the type of operation, forages may be used as a feed source to maintain the pregnant beef cow or grow a weaned calf. In a study involving Saskatchewan beef producers, Highmoor (2005b) reported that the average direct cost of feeding and bedding cows was $1.00 per cow per day. In addition, the average yardage cost during the same winter-feeding period was $0.79 per cow per day. This total cost of $1.79 per cow per day was $1.00 more per cow per day than the average grazing cost of $0.80 per cow per day (McCartney et al. 2004). Additionally, Lang (2006) reported that the average grazing cost ranged from $0.69 to $0.80 per cow per day for 2002 to 2005, compared to the direct cost of winter feed which ranged from $0.99 to $1.28 per cow per day.

This section will evaluate the economic returns of forage based systems compared to the economic returns for annual cropping at Lanigan, Saskatchewan in each year. The revenues, costs and net return to equity, labor and personal draw (take-home pay or cash available for withdrawal from a business to pay personal living expenses) were determined along with the revenues, costs and returns which would have resulted had the land been annually cropped with spring wheat or feed barley. This work is an extension of research conducted at the Western Beef Development Center's Termuende Research Ranch in 2000 and 2001 (Thompson and Lardner 2002).

Perennial Forages

Revenue

Revenue generated in the forage based systems was the result of custom grassing stockers based on kg of weight gain. In this calculation, the custom grassing rate was $0.858 per kg for 2004, 2005 and 2006. The rate increased to $0.99 per kg for 2007 and 2008. The grassing rate was then multiplied by beef production per hectare (Table 7; kg ha^{-1}) to determine revenue generated from each species.

Costs

In each grazing system, variable or operating costs included supplemental feed and minerals, veterinary and medicine costs, fertilizer and custom work. Fixed costs in the grazing system included fence and water repair, fence and water depreciation and investment, insurance and license, grass establishment costs and land rent. Seed and

grass establishment costs were not included for the long established stand of crested wheatgrass (CONTROL) due to stand longevity. AC Goliath crested wheatgrass was assumed to have a stand life of 20 years; therefore, all seed and grass established costs were amortized over 20 years even though producers would likely incur those costs in the first year establishment. The tall fescue and bromegrasses were assumed to have a stand life of 12 years; costs were amortized over 12 years for those varieties.

Seeding rates for each species were based on recommended seeding rates by seed distributors and growers. Seeding rates for each species were meadow bromegrass at 11.2 kg ha^{-1}, smooth bromegrass at 9 kg ha^{-1}, hybrid bromegrass at 11.2 kg ha^{-1}, crested wheatgrass at 10 kg ha^{-1} and tall fescue at 5 kg ha^{-1}. Pastures were seeded using disk press drills after areas were disked twice with tandem disks. Based on herbicide application as previously described, there were one-time weed control cost of \$109.84 ha^{-1} (herbicide) (Saskatchewan Ministry of Agriculture) and \$12.15 ha^{-1} (application). All field work was valued at the average custom rate per ha (which included the power unit, implement and labour) from the Saskatchewan Ministry of Agriculture *Farm Machinery Custom and Rental Rate Guide*. At seeding, 56 kg actual N ha^{-1} was placed with the seed. Each year all pastures were fertilized with 79 kg actual N ha^{-1} and 22 kg actual P ha^{-1} of liquid fertilizer. All fertilizer prices and costs of custom application were based on prices from Blair's Fertilizer Ltd., Lanigan, Saskatchewan.

Supplemental salt and minerals was estimated to be \$8.08 ha^{-1} (Lardner 2004). Veterinary and medicine costs were estimated at \$12.35 per hectare. Fence and water repair costs were estimated at \$3.43 ha^{-1} yr^{-1} and fence, water depreciation and investment were estimated at \$11.14 ha^{-1} yr^{-1}. In addition, insurance and licenses were estimated to cost \$4.69 ha^{-1}. Finally, the cost of land rent was assumed to be \$61.75 ha^{-1} each year of the study.

Annual Crops

Revenue

For comparison, revenue from an annual cropping system was calculated if either spring wheat or feed barley had been grown on the same land base. Revenue was calculated by using mean bushel yield per ha for the Lanigan area (Rural Municipality 309) from Saskatchewan Ministry of Agriculture web-site (www.agriculture.gov.sk.ca) for each year. The bushel yield was multiplied by the Canadian Wheat Board's final price for spring wheat (1 CWRS 13.5) or feed barley (1 CW Feed Barley) less the freight rate for Lanigan. Freight rate was not deducted for feed barley as it was assumed that it would be sold into a local market.

Costs

Estimation of the costs to annual crop the land was calculated by using Saskatchewan Ministry of Agriculture Crop Planning Guides for the Black Soil Zone. Costs were based on the crop being direct seeded into stubble. Variable costs included seed, chemical, fertilizer, machinery fuel and repairs, crop insurance premium, custom work, interest, utilities, office and miscellaneous expenses. Fixed costs included building

repair, machinery and building depreciation and interest, insurance, licenses and land rent.

Results

Annuals

Average revenue generated in 2004, 2005, 2006, 2007, 2008 for spring wheat and feed barley was $-152.42 and $-191.79 ha^{-1}, $-127.48 and $-178.96 ha^{-1}, $67.02 and $155.77 ha^{-1}, $428.52 and $369.31 ha^{-1}, $92.14 and $-121.61 ha^{-1}, respectively (Tables 6 and 7).

Perennials

Average revenue generated in 2004 for CWG, HBG1, HBG2, SBG and MBG pastures was $-16.50, $11.64, $-26.74, $-16.93 and $2.55 ha^{-1}, respectively (Table 7). Average revenue generated in 2005 for CWG, HBG1, HBG2, SBG, MBG, TF and CONTROL pastures was $82.95, $84.70, $-69.03, $3.46, $11.17, $44.08 and $-99.03 ha^{-1}, respectively (Table 7). Average revenue generated in 2006 for CWG, HBG1, HBG2, SBG, MBG, TF and CONTROL pastures was $102.03, $97.78, $84.91, $-24.64, $77.01, $54.58 and $-9.06 ha^{-1}, respectively (Table 7).

Average revenue generated in 2007 for CWG, HBG1, HBG2, SBG, MBG, TF and CONTROL pastures was $80.46, $161.61, $97.85, $61.66, $123.75, $210.74 and $-18.46 ha^{-1}, respectively (Table 8). Average revenue generated in 2008 for CWG, HBG1, HBG2, SBG, MBG, TF and CONTROL pastures was $102.03, $97.78, $84.91, $-24.64, $77.01, $54.58 and $-9.06 ha^{-1}, respectively (Table 8). Finally, a negative average net revenue was generated from grazing the CONTROL paddocks (>40 yr stand) in all years of the study, ranging from $-9.60 to $-128.95 ha^{-1} (Tables 7 and 8).

Table 7. Revenue, costs and net return associated with grazing pasture species at Lanigan, Saskatchewan (2004-2006)

Item[z]	Forage Production System ($ ha^{-1})							Annual Crop System ($ ha^{-1})	
	CWG	HBG1	HBG2	SBG	MBG	TF	CONTROL	Spring Wheat	Feed Barley
2004									
Revenue	197.18	237.72	199.34	206.74	227.09	-	-	220.62	169.99
Variable Costs	122.93	127.65	127.65	125.24	126.11	-	-	230.53	219.26
Fixed Costs	90.74	98.43	98.43	98.43	98.43	-	-	142.52	142.52
Total Costs	213.68	226.08	226.08	223.66	224.54	-	-	373.04	361.78
Net Return to Labor, Equity & Personal Draw	-16.50	11.64	-26.74	-16.93	2.55	-	-	-152.42	-191.79
2005									
Revenue	301.16	315.32	162.60	231.66	240.24	270.70	106.82	264.03	199.06
Variable Costs	124.84	124.84	124.84	124.84	124.84	124.84	124.24	243.04	229.55
Fixed Costs	93.36	105.77	105.77	103.35	104.23	101.78*b*	81.02d	148.47	148.47
Total Costs	218.21	230.62	230.61	228.02	229.08	226.62*b*	205.86d	391.51	378.03
Net Return to Labor, Equity & Personal Draw	82.95	84.70	-69.03	3.46	11.17	44.08	-99.03	-127.48	-178.96
2006									
Revenue	320.90	329.05	316.18	204.21	306.74	281.85	196.91	479.65	551.79
Variable Costs	125.50	125.50	125.50	125.50	125.50	125.50	125.50	263.35	246.74
Fixed Costs	93.36	105.77	105.77	103.35	104.23	101.78	81.02	149.28	149.28
Total Costs	218.86	231.27	231.27	228.85	229.73	227.28	206.51	412.63	396.02
Net Return to Labor, Equity & Personal Draw	102.03	97.78	84.91	-24.64	77.01	54.58	-9.60	67.02	155.77

[z]CWG=AC Goliath crested wheatgrass; HBG1=AC Knowles hybrid bromegrass seeded 1999; HBG2=AC Knowles hybrid bromegrass seeded 2003; MBG=Paddock meadow bromegrass; SBG=Carlton smooth bromegrass; TF=Courtenay tall fescue (not grazed 2004); CONTROL=crested wheatgrass (not grazed 2004).

Table 8. Revenue, costs and net return associated with grazing pasture species at Lanigan, Saskatchewan (2007-2008)

Item[1]	Forage Production System ($ ha^{-1})							Annual Crop System ($ ha^{-1})	
	CWG	HBG1	HBG2	SBG	MBG	TF	CONTROL	Spring Wheat	Feed Barley
2007									
Revenue	327.99	421.54	357.79	319.18	382.14	466.69	216.71	833.13	756.66
Variable Costs	156.79	161.50	161.50	159.09	159.96	157.51	155.96	250.95	233.69
Fixed Costs	90.74	98.43	98.43	98.43	98.43	98.43	79.21	153.66	153.66
Total Costs	247.53	259.93	259.93	257.51	258.39	255.94	235.17	404.61	387.35
Net Return to Labor, Equity & Personal Draw	80.46	161.61	97.85	61.66	123.75	210.74	-18.46	428.52	369.31
2008									
Revenue	199.68	-	227.80	-	-	379.27	127.51	586.38	348.21
Variable Costs	178.08	-	182.79	-	-	178.80	177.25	343.48	319.05
Fixed Costs	90.74	-	98.43	-	-	98.43	79.21	150.77	150.77
Total Costs	268.82	-	281.22	-	-	277.23	256.46	494.25	469.82
Net Return to Labor, Equity & Personal Draw	-69.13	-	-53.42	-	-	102.04	-128.95	92.14	-121.61

[1]CWG=AC Goliath crested wheatgrass; HBG1=AC Knowles hybrid bromegrass seeded 1999 (not grazed 2008); HBG2=AC Knowles hybrid bromegrass seeded 2003; MBG=Paddock meadow bromegrass (not grazed 2008); SBG=Carlton smooth bromegrass (not grazed 2008); TF=Courtenay tall fescue; CONTROL=crested wheatgrass.

Economic comparison

It is suggested that the grain cycle is a 10-year cycle. From 1997 to 2008, the long term average yield in the Lanigan area was 85 and 125 bu ha^{-1} for spring wheat and feed barley, respectively (SMA 2008). In addition, the average price per bushel for spring wheat and feed barley for the same time period was \$4.20 and \$2.90 bu^{-1}, which would generate revenues of \$357.00 and \$362.50 ha^{-1}, respectively.

However, average variable costs for growing annual crops in the current 5-year study were double the costs for managing perennial pastures, averaging \$266.27 and \$249.66 ha^{-1} for spring wheat and feed barley, respectively (Tables 7 and 8). Similarly, fixed costs were also higher in the annual cropping system, averaging \$148.94 ha^{-1} for both spring wheat and feed barley. The resulting average total costs for growing an annual crop; \$407 ha^{-1} is 83% higher than average total costs for the forage based system at \$222 ha^{-1}. While the average total costs was \$222.21 ha^{-1}, to generate revenue of \$287.48 ha^{-1} for all perennial forages over the 5 years, the average total costs needed to generate average revenue of \$479.28 and \$405.09 ha^{-1} for spring wheat and feed barley was \$415.21 and \$398.60 ha^{-1}, respectively. Therefore, in the current study, the potential to generate revenue was not as high in the forage based systems as growing annual crops, but neither was the yearly cash outlay (variable costs) or financial risk.

When averaged over the 5-year study period, spring wheat and feed barley had returns to labor, equity and personal draw of \$61.55 and \$ 6.54 ha^{-1}, respectively. In comparison, when net returns for the forage varieties are averaged over the same 5-year period, average net returns for smooth bromegrass, hybrid bromegrass (HBG2), crested wheatgrass, meadow bromegrass, hybrid bromegrass (HBG1) and tall fescue (TF) were \$5.89, \$6.71, \$35.96, \$53.62, \$88.93 and \$102.86 ha^{-1}. This indicates that net returns from stocker systems grazing meadow bromegrass, hybrid bromegrass or tall fescue can generate similar or greater profit than growing annual cereals over the long term. Finally, in comparison to average net returns from growing spring wheat, grazing hybrid bromegrass or tall fescue pastures generated 44 and 67% greater profit over the long term.

An advantage to custom grassing stockers is that this system has the potential to provide a similar or more consistent revenue source when compared to annual cropping systems. When growing annual crops, weather can be a major factor in determining potential revenue. In the Lanigan region, perennial pastures in good condition may better withstand prolonged heat and early or late frosts much better than annual crops such as spring wheat or barley. If there is less potential risk to the overall revenue of the forage based system, and the total costs are lower, it would suggest that custom grassing stockers on new varieties of meadow bromegrass, hybrid bromegrass, crested wheatgrass and tall fescue may be economically advantageous.

The current study used custom grazing of yearling steers to generate revenue from the perennial pasture systems; however, the likelihood that producers will be grazing cow-calf pairs is just as great. In a recent study by the Western Beef

Development Centre evaluating the economics of conversion from grain production to grass production (2000 to 2005) at Weldon, Saskatchewan, rotational grazing of perennial pasture (meadow bromegrass-alfalfa) by cow-calf pairs provided greater net return ($57.94 ha^{-1}) compared to annual cropping systems ($28.80 ha^{-1}) (Lang 2006). Thus, the current study results are similar to those reported by Lang (2006). Finally, grazing perennial pastures can provide comparable, if not superior, net returns compared to annual cropping systems.

IMPLICATIONS

When these cultivars were managed under a grazing system with good fertility in the Lanigan region, forage yield (CDMY) in most years was similar. However, in the first year all three brome grasses out-yielded crested wheatgrass. In 2005, the crested wheatgrass variety, AC Goliath yielded greater than other varieties. In addition, the variety AC Knowles had superior yield compared to the long established crested wheatgrass control. Totaled over all years, new forage varieties produced superior yields compared to control paddocks. Tall fescue, smooth bromegrass, crested wheatgrass, meadow bromegrass and hybrid bromegrass produced 37, 40, 63, 74, 79 and 114% greater total yield than the control pasture.

All brome cultivars had similar crude protein, neutral detergent fiber, acid detergent fiber and in vitro organic matter digestibility levels. In previous research, it was suggested that meadow bromegrass had lower quality than smooth bromegrass and that hybrid bromegrass would have forage quality intermediate to the parental lines. These results suggest that forage quality is similar between meadow, smooth and hybrid bromegrasses, but superior to the control (> 40 yr) stand of crested wheatgrass. AC Goliath crested wheatgrass and tall fescue also showed superior forage quality compared to the quality of control pasture forage. The results for crude protein, acid detergent fiber and in vitro organic matter digestibility did not show a consistent ranking among the study grasses; however, tall fescue tended to have lower neutral detergent fiber levels than either hybrid bromegrass or crested wheatgrass but this observation was not always different. Higher fiber content in 'AC Goliath' and hybrid bromegrass pastures did not appear to lower *in vitro* organic matter digestibility.

Based on etiolated regrowth of grasses, AC Goliath' crested wheatgrass had the greatest energy reserves which may account for the observed early spring growth of this species. There were no differences in energy reserves between meadow bromegrass, smooth bromegrass, hybrid bromegrass or the long established stands of crested wheatgrass. When the energy reserves of these plants were measured, pastures had been established for some time and stand age may have masked any species effect. The ranking of species in relation to energy reserves would place 'AC Goliath' crested wheatgrass first, followed by hybrid bromegrass, tall fescue and finally, the long established crested wheatgrass control pastures. While it is generally accepted that defoliation or grazing can decrease plant energy reserves, it appears that if a sufficient recovery period is provided after grazing, plants can replenish reserves to levels of un-grazed plants by the following spring. Thus, grazing management plans should consider

not only the timing of defoliation in relation to energy reserves but also the intensity and frequency of defoliation and its effect on the plant's ability to photosynthesize, maintain and/or replenish energy reserves.

Data from this study suggests that all grass species evaluated will produce acceptable animal gains for grassing stockers. However, animal grazing days were greater for new varieties in the study compared to stockers grazing the control paddocks. Over the five years, bromegrass species had greater grazing days than the crested wheatgrass variety, suggesting that all three species can be utilized for late spring and summer pasture. In addition, tall fescue provided more animal grazing days than the other grasses and control pastures. All species produced greater total beef production compared to control pastures. In most years tall fescue and hybrid bromegrass produced similar or greater total beef production per hectare than the other varieties. Therefore, even though these grasses have good production potential, the production may be seasonal (early to mid summer) and there may be limitations as to time of use for these species. Grazing tall fescue may require more detailed grazing management to optimize its grazing potential in the Lanigan region.

The 45% reduced total costs to grow a perennial forage compared to growing an annual crop and the increase in net returns per hectare observed in this study clearly shows how perennial forage systems, over a 5-year period, can return greater profit to the agriculture enterprise.

Based on the results of this grazing study, beef producers can graze stocker cattle on new varieties of perennial grass pastures during the summer grazing season and expect to maintain adequate levels of grazing animal performance and pasture production. The study demonstrated that three bromegrasses, crested wheatgrass and tall fescue work well in a complementary grazing system while other seeded forages or native rangeland can fill the mid to late summer grazing period.

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PERSONNEL INVOLVED

Ms Charlotte Ward - MSc Graduate Student, Department of Animal & Poultry Science, University of Saskatchewan.

Dr Bart Lardner - Project Supervisor, Western Beef Development Centre; Department of Animal & Poultry Science

Mr Duane McCartney, Agriculture & Agri-Food Canada, Lacombe AB

Ms Kathy Lang, Beef Economist, Western Beef Development Centre

PROJECT EXTENSION ACTIVITIES & PUBLICATIONS:

FIELD DAYS:

Project results presented to producers at WBDC Summer Field Days:

- June 28, 2005
- June 27, 2006

PUBLICATIONS:

Published Conference Proceedings:

HA Lardner, C Ward, L Froehlich and L Zemlak. 2008. Evaluation of the Productivity and Grazing Capacity of Cool Season Grasses. Proceedings of the Joint International Grassland Congress – International Rangeland Congress. Hohhot, Inner Mongolia Province, China. Session B – Grassland-Rangelands Production Systems. pp. 55.

C Ward and HA Lardner. 2006. Yield, Quality and Etiolated Growth of New Forage Varieties under Grazed Conditions. Proceedings of the Canadian Society of Animal Science 2006 Annual Meeting. Halifax NS. pp. 64.

C Ward and HA Lardner. 2006. Performance of New Forage Varieties f[illegible] Grazing. Proceedings of the Soils & Crops Workshop. University of Saskatchewan. Saskatoon SK. March 2. pp. 11-12.

Articles Published:

- Journal of Animal Science *Ward, CI and Lardner, HA. 2007. Evaluation of forage quality, grazing capacity and intake of cool season grasses. Journal of Animal Science. 85 (Suppl. 1) :107 (Abstr.).*
- Range and Pasture Management Magazine Fall 2004 *"Herd Health and Grass".*

WBDC Fact Sheets Published:

- Evaluating New Pasture Varieties

CONFERENCES:

Research results were presented at the following meetings:

- 2009 Saskatchewan Beef Symposium, Saskatoon, SK. February 2009 (paper presentation)
- American Society of Animal Science Annual Conference, San Antonio, TX. July 2007 (poster presentation)
- Canadian Society of Animal Science Annual Conference, Halifax, NS. June 2006 (paper presentation)

Statement of Expenditures

A final statement for the project is included. All expenditures were in compliance with ADF guidelines. This project was finalized with the successful thesis defense by Ms Ward in January 2009. A copy will be forwarded to Agriculture Development Fund, Agriculture Research Branch, Ministry of Agriculture.

PROJECT EXPENDITURES:

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APPENDIX

Figure A1. Species paddocks at Western Beef Development Center Termuende Research Ranch at Lanigan, Saskatchewan.

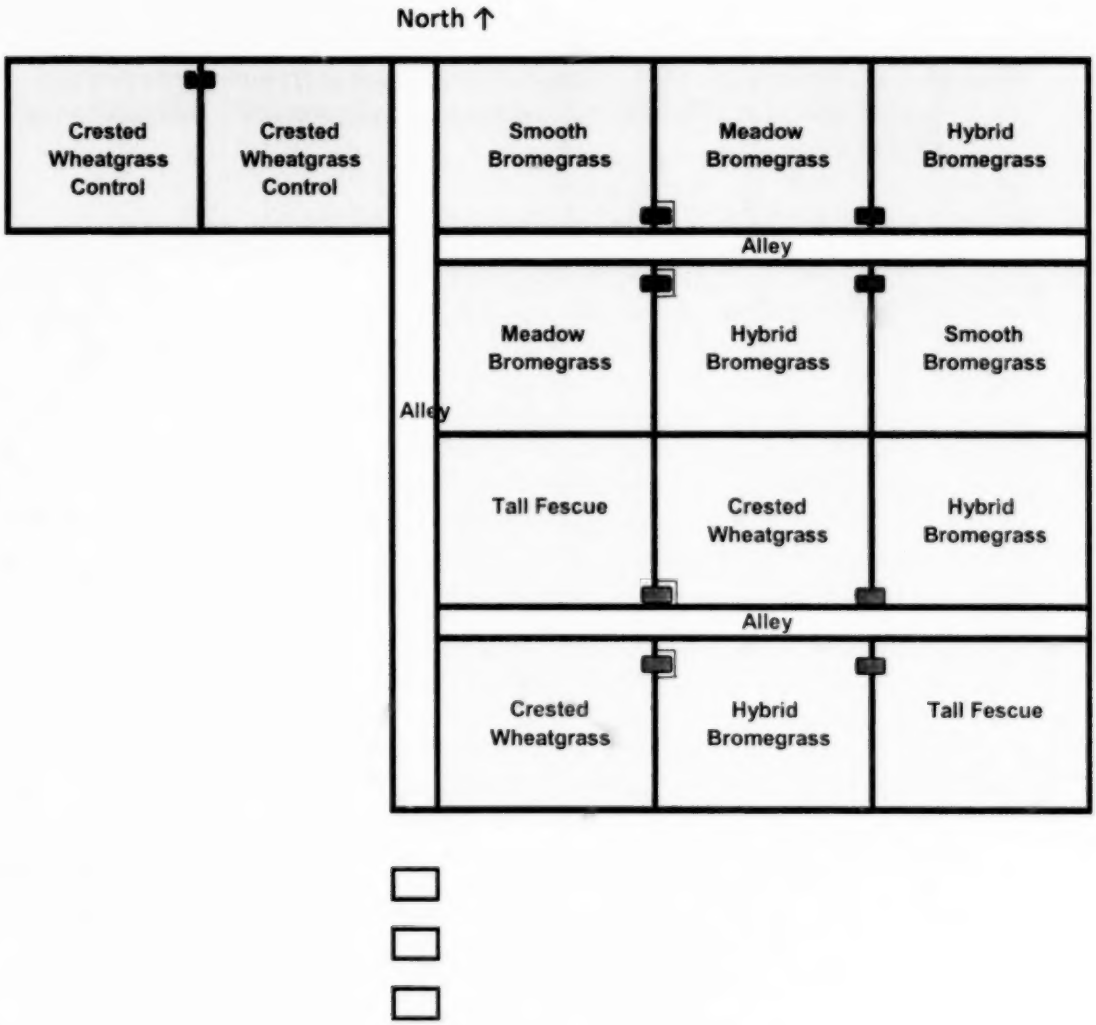

Table A.1 Composition of range mineral fed *ad libitum* to steers[z]

Element	Concentration
Calcium (%)	16.0
Phosphorus (%)	16.0
Iron (mg kg^{-1})	450
Iodine (mg kg^{-1})	125
Manganese (mg kg^{-1})	5300
Copper (mg kg^{-1})	4000
Cobalt (mg kg^{-1})	40
Zinc (mg kg^{-1})	10000
Fluorine (mg kg^{-1})	2000
Selenium (mg kg^{-1})	60
Vitamin A (IU kg^{-1})	200000
Vitamin D (IU kg^{-1})	45000
Vitamin E (IU kg^{-1})	40

[z]Feed-Rite Hi C-N-Z (1:1) Beef Mineral Premix with Weatherguard, Feed-Rite, Division of Ridley, Inc.).